Space Weather Technical Forecast

Issued on Saturday, 02 December 2023 at 13:15 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Further G1-G2 Minor to Moderate storms expected at first, easing later day 1 (02 Dec). Chance of M-class flares (R1-R2 Blackouts).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity is at Moderate levels with the largest flare of the previous 24 hours a M1.0 fare at 01/2120 UTC from AR3500. There are seven sunspots on the disc. AR3509 appears relatively stable and is assessed as Cai/Beta. AR3500 in the southwest remains the largest and most significant region, however the opposite polarity spots which formed a weak delta spot in the north-eastern part of the group, appear to have separated and hence its now classified as a Eki/Beta-Gamma. The remaining regions on the visible disc are all relatively simple, and predominantly mature and stable unipolar "H" spots.

There are a large number of filaments on the Earth-facing disc. A filament lift off in the SE disk was observed around 01/1400 UTC, the resulting CME is not expected to be Earth directed. A CME signature was observed in association with the most recent M1.0 flare from AR3500, after initial analysis this currently looks to pass ahead of earths orbit on Day 4 (05th November), although is under re-analysis for possible risk of a glancing blow. Other CME signatures in coronagraph imagery during the past 24 hours are considered far-sided and thus not Earth-directed.

Solar Wind / Geomagnetic Activity: Solar wind speeds, as observed by ACE and DSCOVR at L1 began the period around 500-560 km/s, these elevated levels associated with the arrival of the CME earlier on 01 Dec, levels persisted at Elevated until around 02/0200UTC when they dropped to Slightly elevated levels, which they are currently at around 470 km/s.

Density was Above Average to start, peaking at around 21 pppc at 01/1056 UTC, before slowly reducing during the period to average levels.

The Interplanetary Magnetic Field (IMF), Bt, was initially strong, peaking at 27nT at 02/1325 UTC following the CME arrival and remaining at strong levels until around 02/0400 UTC when it slowly reduced to moderate. The north-south component of the IMF (Bz), was strongly positive at first (peak 27nT at 01/1323 UTC) before easing to weakly or moderately negative until around 0200UTC, where it slowly turned weakly positive as the IMF underwent slow rotation at L1 within the magnetic cloud, finishing moderately positive at 11nT at 021200UTC.Phi angle was largely negative throughout (towards the Sun).

Resultant Geomagnetic activity was initially G3/Strong Storm levels during 01/0900-1200 UTC, with further G1-G2 Minor to Moderate Storm intervals recorded 01/1200-1500, 1800-2100, 2100-2400 and 0000-0300, before falling to Quiet from 0600-0900.

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux remained at Background levels. GOES16 high energy (greater than 2MeV) electron flux has been at background. The associated 24-hour fluence has remained below the Active threshold (1e8 integrated pfu) with a steady then slightly declining trend. The observation at 01/0000 UTC was 1.39e7 integrated pfu.

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Met Office Space Weather Technical Forecast

Four-Day Space Weather Forecast Summary

Solar Activity: Low to Moderate with a chance of further isolated M-flares (R1-R2 Blackout), and a very slight chance of an isolated X-class flare (R3 Blackout). AR3500 in the southwest disc is most likely to be the source of any significant flares.

Solar Wind / Geomagnetic Activity: Geomagnetic activity and solar winds should slowly wane during the rest of Day 1 (02 Dec) as current CME influence begins to ease. Activity expected to be generally Quiet to Unsettled into day 2 (02 Dec) as winds likely return to background levels, remaining so until the arrival of the HSS Day 3 (04 Nov) associated with the large CH76/- approaching the meridian. The onset of the HSS should see winds reach Elevated to Strong levels and geomagnetic activity increase to Active to G1-G2/Minor-Moderate Storm (Kp 4-6) levels for a time. Although currently considered unlikely, the possible risk of a glancing blow of the CME from the 01 December may give a further risk of G1-G2/Minor-Moderate Storm (Kp4-6) on Day 4 (05 Dec).

Energetic Particles / Solar Radiation: GOES16 high energy proton flux is expected to remain at Background levels. However, any significant flares, particularly from AR3500, or any notable filament eruptions will bring a chance of flux levels increasing, with a slight chance of approaching or perhaps exceeding the S1 Minor Radiation Storm level.

Electron flux has fallen to Background levels following the arrival of CMEs on the 01 December. Some recovery of flux to Moderate or High levels at diurnal peak is possible during day 2 (03 Dec), only to likely decrease to Background levels again as geomagnetic activity increases into day 3 and 4 (04-05 Dec) with the arrival of the HSS from CH76/- and possible CME glancing blow on Day 4 (05 Dec).

The associated 24 hour electron fluence is expected to remain below the Active threshold (1e8 integrated pfu). However, a rising trend is likely from day 2 onward, once any CME influence recedes with a slight chance of exceeding the Active threshold into day 3 (04 Dec).

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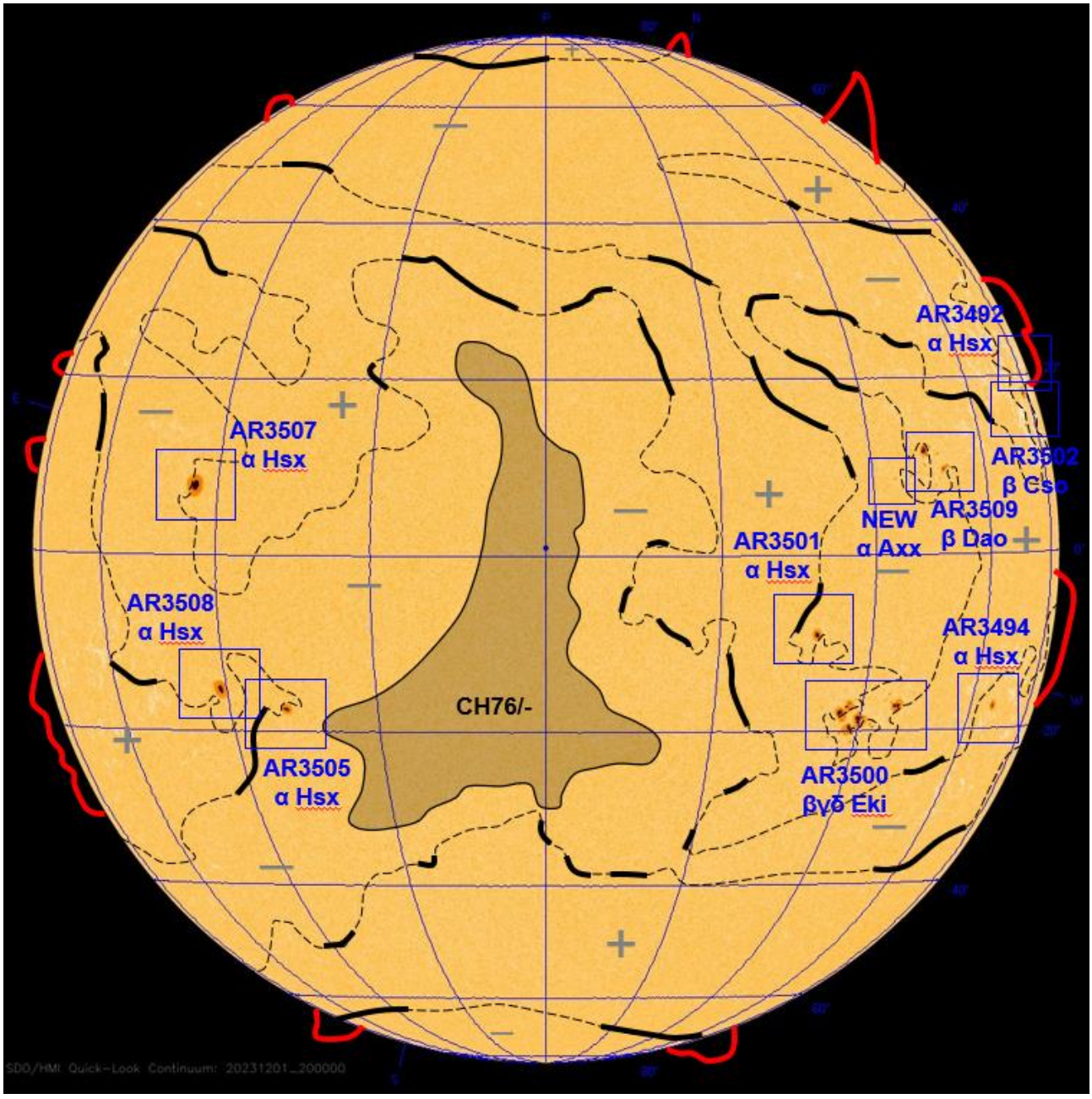
Figure 1. Solar Analysis Valid 02/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

The arrival of the notable CME from 28 Nov is still giving slightly enhanced solar winds of around 450 km/s, this is expected to gradually subside during the coming 24 hour period. No further CME arrivals are currently expected, however a CME which emanated from the SW disc around 01/2200UTC has been analysed and is currently expected to largely miss ahead of Earth but is currently being reanalysed to see the possible risk of a glancing blow on Day 4 (5th December).

Current CME influence expected to slowly wane during day 1 (02 Dec), with solar winds expected to gradually reduce, likely falling to Background levels during day 2 (03 Dec). the next forecast enhancement is the arrival of a High Speed Stream (HSS) associated with the large CH76/- approaching the meridian. The expected onset of this feature is expected at some point during day 3 (04 Dec). CH76/- is a persistent feature, and is similar in size and position to the previous rotation, however during the previous rotation a CME arrival masked the initial influence of the coronal hole. Elevated to Strong winds of around 550-650km/s are expected though with slightly reduced confidence.

Geomagnetic activity expected to be generally Quiet to Unsettled during the rest of Day 1 (02 November) and into Day 2 (02 Dec), remaining at similar levels until the arrival of the HSS Day 3 (04 Nov). The onset of the HSS should see activity increase to Active to G1-G2/Minor-Moderate Storm (Kp 4-6) levels before easing. Although currently considered unlikely, the possible risk of a glancing blow of the CME from the 01 December may give a further risk of G1-G2/Minor-Moderate Storm (Kp4-6) on Day 4.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	5	5	60	50
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

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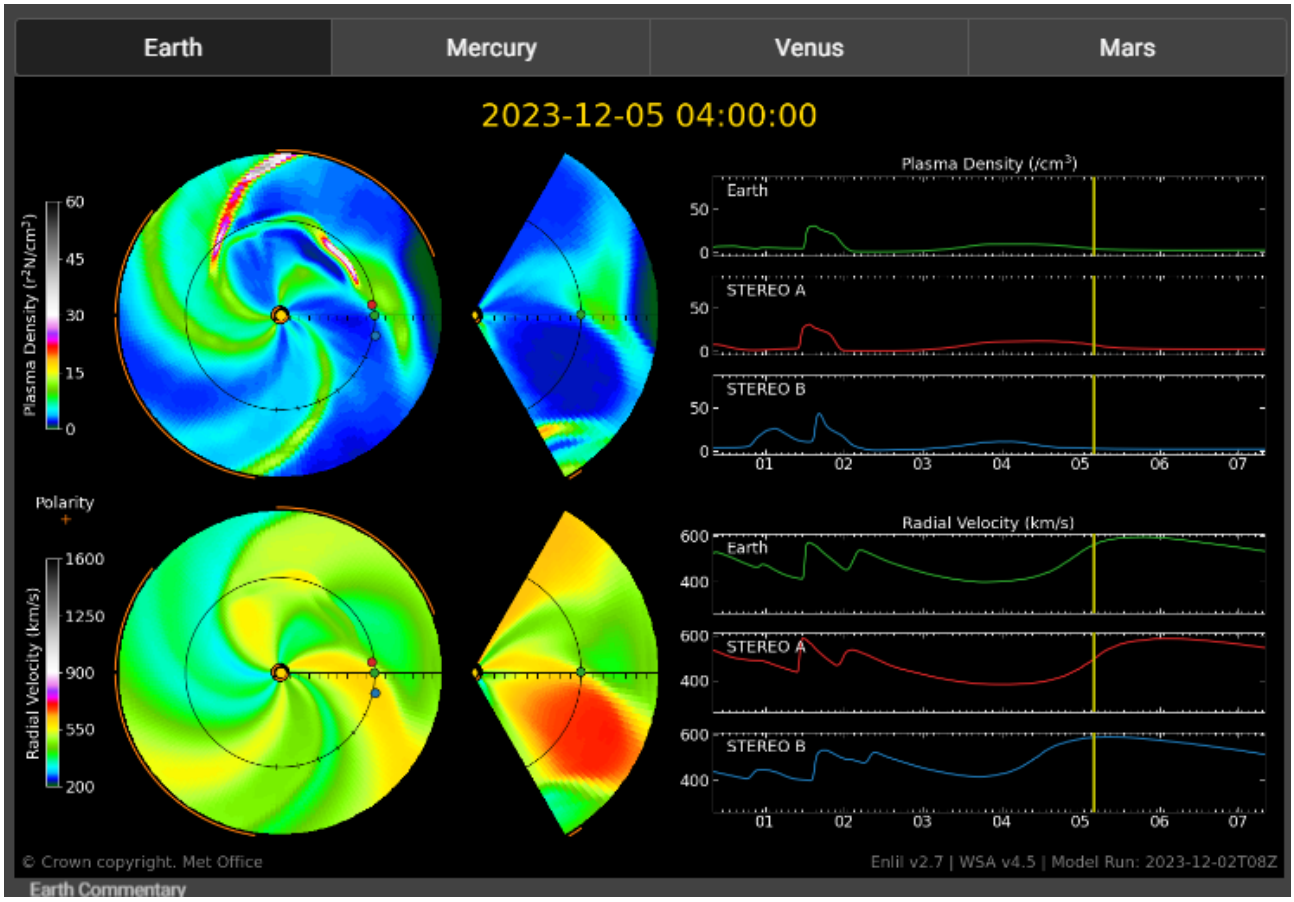
Figure 2 Latest MOSWOC ENLIL output showing CME from the 01 Dec currently expected to miss ahead of Earth, and the expected HSS into the period.



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Radio Blackouts - X-Ray Flares:

Solar activity is at Moderate levels Low to Moderate activity is expected to continue in the short term with a chance of further isolated M-flares (R1-R2 Blackout), and a very slight chance of an isolated X-class flare (R3 Blackout). The bulk of the current flare risk is attributed to AR3500 and this region will be approaching the limb by day 4 (05 Dec). No significant oncoming regions suggested by far side data at this stage.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	50	40	35	35
Very Active	R3 to R5 X Class	No	5	5	5	5

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Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux observed by GOES16 is currently at Background and expected to remain at this level. However, with the number of spots and filaments on the disc there is a chance of flux increasing in response to any significant flares or eruptions. The main risk is from AR3500, in the southwest disc. This was the source of an M9.8 flare late on 28 Nov, and while no proton response was observed at Earth on this occasion, any subsequent flares will also have the potential to increase the observed proton flux.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	10	10	10	10
Very Active	**≥ S3 ***	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

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High Energy Electrons Event (≥ 2MeV):

Electron flux has fallen to Background levels following the arrival of recent CMEs ion the 01 December. Some recovery of flux to Moderate or High levels at diurnal peak is possible during day 2 (03 Dec), only to likely decrease to Background levels again as geomagnetic activity increases into Day 3 and 4 (04-05 Dec) with the arrival of the HSS from CH76/- and possible CME influences on Day 4 (05 Dec)

The associated 24 hour electron fluence is expected to remain below the Active threshold (1e8 integrated pfu), as supported by REFM. However, a rising trend is likely from day 2 onward, once any CME influence recedes with a slight chance of exceeding the Active threshold into day 3 (04 Dec).

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	10	20	10
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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